

## Galen: Developer of the Reversal Design?

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Galen, known to psychologists largely for his personality theory of the four temperaments, diagnosed the cause of a patient's symptoms with a form of reversal design long before its formal description (e.g., Sidman, 1960).

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The Greek physician Galen (ca 129 to ca 200) was probably the most influential writer of all time on medical subjects. For nearly fifteen hundred years his works were an unimpeachable authority on medicine in many different lands. A bitter polemicist yet broad in view, Galen was both a careful, accurate observer and an uncritical believer, a dogmatic authoritarian and an original thinker. (Lyons & Petrucelli, 1987, p. 251)

Galen is known to psychologists largely for his personality theory of the four temperaments, tied to Hippocrates' four humors. However, his method of diagnosing the basis of one of his patients' symptoms indicates that he used a form of reversal design long before its formal description (e.g., Sidman, 1960).

*History of systematic single-subject research.* The development of single-subject research is often attributed (e.g., Hersen & Barlow, 1976) to 19th century physiologists such as Johannes Müller (1834–1838/1840–1842) and Claude Bernard (1865/1927). Indeed, systematic use of such experimental methods may well owe to them and to the originators of psychophysics, Ernst Weber (e.g., 1846) and Gustav Fechner (1860).

Kazdin (1978, p. 92) suggested that a “particularly noteworthy” direct

influence on Skinner's methodology was his postdoctoral fellowship at Harvard Medical School with the physiologist W. J. Crozier, to whom Skinner referred briefly in *The Behavior of Organisms* (1938) and more extensively in “A Case History in Scientific Method” (1956). According to Kazdin, Crozier focused not only on study of the whole organism, as did his mentor Loeb, but also on variations in behavior of single subjects. Crozier argued that such variation was a function of variations in both external environmental conditions and internal organismic ones. However, individual uses of such methods occurred far earlier.

*Examples of early single-subject research and application.* Many single-subject research and behavior modification methods have isolated and apparently noninfluential precursors. Goethe used a form of exposure therapy to cure himself of fear of heights by forcing himself repeatedly to climb to the top of a church tower until his fear disappeared (Bringmann, Krichew, & Balance, 1970). Benjamin Franklin (1909) in his autobiography describes the system he used to “arrive at moral perfection” (p. 78). Finding that simply trying to do right and avoid wrong failed: “While my care was employed in guarding against one fault, I was often surprised by another; habit took the advantage of inattention; inclination was sometimes too strong for reason” (p. 78). He then (a) listed 13 virtues, each with “a short precept” (operational definition?) (e.g., “Tem-

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perance. Eat not to dullness; drink not to elevation," p. 79); (b) devised charts listing the virtues vertically and days of the week horizontally; and (c) resolved to attempt to increase one at a time while recording the occurrence of all. He claimed success in instituting all except Order ("Let all your things have their places; let each part of your business have its time," p. 79), which "cost me so much painful attention, and my faults in it vexed me so much, and I made so little progress in amendment, and had such frequent relapses" (p. 84) that he essentially gave up. (The present author is all too familiar with the intransigence of Order to modification.) Franklin wrote that he planned to publish a summary of his virtues and reasons for adhering to them, but had not, owing to the need to attend to private and public business. Of course Franklin was first with many things, and use of a within-subject multiple baseline design across responses (e.g., Kazdin, 1998) may well be one.

*Galen as an empiricist.* Although he propounded many influential but baseless theories, such as vitalism, Galen was "the first and foremost contributor to experimental physiology before Harvey" (Garrison, 1929, p. 115). Through dissections brains of apes, oxen, and swine, he (a) described the pia mater and dura mater, corpus callosum, third and fourth ventricles, fornix, and several other brain structures; (b) discovered the sympathetic nervous system; (c) differentiated between sensory and motor nerves; (d) described seven of the 12 pairs of cranial nerves; (e) first accurately described the mechanism of respiration; and (e) demonstrated that sectioning of different levels of the spinal cord produced varying degrees of paralysis and that sectioning of the recurrent laryngeal nerve resulted in loss of voice (Garrison, 1929; Guthrie, 1946). Unfortunately, human dissection was illegal in Galen's time, which combined with his

propensity for overgeneralization, led to many erroneous conclusions that persisted until and, in some cases, after the Renaissance.

*Galen's implementation of a reversal design.* Galen's method to diagnose the cause of a patient's symptoms is unique in terms of antiquity, design, and purpose. In working with a young female patient, he developed and applied a version of the single-subject reversal design. Frequently summarized but rarely fully presented, Galen's complete description is here given in translation (Brock, 1929, pp. 213–214, as quoted in Jackson, 1969, p. 365):

I was called in to see a woman who was stated to be sleepless at night and to lie tossing about. Finding that she had no fever, I made a detailed inquiry into everything that had happened to her, especially considering such factors as we know to cause insomnia. But she either answered little or nothing at all, as if to show that it was useless to question her. Finally, she turned away, hiding herself completely by covering the bedclothes over her whole body, and laying her head on another small pillow, as if desiring sleep.

After leaving I came to the conclusion that she was suffering from one of two things: either from a melancholy dependent on black bile, or else trouble about something she was unwilling to confess. I therefore deferred till the next day a closer investigation of this. ...

After I had diagnosed that there was no bodily trouble, and that the woman was suffering from some mental uneasiness, it happened that, at the very time I was examining her, this was confirmed. Somebody came from the theatre and said that he had seen Pylades dancing. Then both her expression and the colour of her face changed. Seeing this, I applied my hand to her wrist, and noticed that her pulse had suddenly become irregular (*anomalous*). This kind of pulse indicates that the mind is disturbed; thus it occurs also in people who are disputing over any subject. So on the next day I said to one of my followers, that, when I paid my visit to the woman, he was to come in a little later and announce to me, "Morpheus is dancing today." When he said this, I found that the pulse was unaffected. Similarly also the next day, when I had an announcement made about the third member of the troupe, the pulse remained unchanged as before. On the fourth evening I kept very careful watch when it was announced that Pylades was dancing, and I noticed that the pulse was very much disturbed. Thus I found out that the woman was in love with Pylades,

and by careful watch on the succeeding days my discovery was confirmed.

*Interpretation of Galen's case.* Galen's design in terms of order of stimulus presentation has a familiar appearance:

Day 1	Day 2	Day 3	Day 4
"Pylades" Behavior change A	"Morpheus" No change B	Third dancer No change C	"Pylades" Behavior change A

The design in terms of stimulus and response change is more complex. The present author's preferred interpretation is a-A-b a-B-a' a-C-a' a-A-b, where A, B, and C refer to stimulus conditions, a to daily baseline pulse and facial expression, b to change in pulse and facial expression following stimulus presentation, and a' to absence of change following stimulus presentation. Other interpretations of the design are likely to be equally or even more appropriate.

The case is in several ways conceptually and methodologically equivalent to common variants of ABAB reversal designs (see, e.g., Hersen & Barlow, 1976; Kazdin, 1998). It (a) measured changes in specific behaviors of a single individual in response to manipulated antecedent conditions presented successively; (b) reversed those conditions from the initial one to two others and then back to the initial one; and (c) analyzed the patient's behavioral (facial color and expression) and physiological (pulse rate) responses relative to a daily baseline. Galen's reversal design necessarily differed from current ones in at least two ways: (a) His measures were qualitative (change or no change) instead of quantitative; and (b) he had no stable baseline across days against which to judge change. But he could not have done otherwise—pulse was a common diagnostic measure in ancient and medieval times (Garrison, 1929), but it could not easily be quantified until Galileo's

discovery of the periodicity of the pendulum in about 1582 and his physician-friend Sanctorius' subsequent development of the pulsilogium, a short pendulum device that quantified pulse rate, in 1602 (e.g., Garrison; Van Helden, 2004). According to Garrison, the Greek physician Herophilus of Chalcedon used a water clock to quantify pulse rate in the fourth century BCE, but the apparatus would have been rather unwieldy for house calls.

Galen's development and application of a version of a single-subject reversal design certainly support Lyons and Petrucelli's (1987, p. 251) suggestion that Galen was both "a careful, accurate observer" and "an original thinker." It also suggests, perhaps surprisingly, his willingness to abandon a humoral diagnosis in response to incompatible empirical evidence. His interpretation was certainly in accord with current views. As Kazdin (1998) stated,

The power of the [reversal] design in demonstrating control of an intervention over behavior is very compelling. If a behavior can, in effect be "turned on and off" as a function of the intervention, this is a powerful demonstration of a causal relation. Few threats to internal validity remain plausible in explaining the pattern of results. (pp. 216–217)

Galen used a single-subject reversal design some 1,700 years prior to the systematic application of such methodology to behavioral research generally (e.g., Hersen & Barlow, 1976; Sidman, 1960; Skinner, 1938) or to patients with behavior disorders specifically (e.g., Skinner, 1954) and 1,400 years before explicit statements in western science of the need for comparisons and control through experiments in making causal inferences (e.g., Bacon, 1620). In addition, by using a design that compared two incompatible hypotheses about the woman's condition (melancholy vs. something troubling her), he used a version of the critical experiment so valued by Bacon and others.

Because Galen was the most influential of all physicians—his then-available writings became virtual dogma, unquestioned for some 1,200 years—one might wonder why his use of a reversal design was not adopted by his contemporaries and successors. Several possibilities may be offered, although at the risk of engaging in “hindzeitgeist.” Foremost, perhaps, Galen did not make much of the case himself, reporting it among others but not seeing its potential wide applicability. He apparently had no students or followers in his time to adopt his methods or carry on his work. He published widely, but some of his works on diagnosis disappeared from the west and were only rediscovered in Arabic copies in the 19th century (e.g., Walser, 1944). His long-term influence was largely through his studies of anatomy and physiology and his approach to medicines and other treatment (Galenism or Galenics).

Of major importance in the decline of Galen’s influence, of course, was Renaissance research that contradicted many of his claims. Vesalius’ (1543) anatomical studies of humans and Harvey’s (1628) experimental demonstration of circulation of the blood provided clear empirical disproof of some of Galen’s most influential work. Vesalius famously pictured a human skull on top of a dog skull to dramatize the errors of Galen’s generalizations from nonhuman dissection, and Paracelsus famously burned Galen’s works in public at the beginning of his lectures (e.g., Garrison, 1929). Research by Renaissance physicians such as Paré and Boyle contradicted other of Galen’s claims about human anatomy, physiology, and treatment. As a result, most of his work apparently fell into disrepute and became ignored. For example, the distinction between sensory and motor nerves was again made only in the 19th century by Bell and Magendie (e.g., Garrison, 1929). An unfortunate exception was contin-

ued acceptance into the 17th century of Galenics by many physicians, regardless of Boyle’s contrary evidence. Culpeper (1672) described in detail Hippocratic and Galenic approaches to treatment and provided an appendix entitled, “A Synopsis of the KEY of Galen’s Method of *Physick*.” Some of Galen’s own works were published well into the Renaissance, for example *Methodi Medendi Vel De Morbis Curandi Libri Xiiii* (Galen, 1546). His theory of the four temperaments, commonly accepted virtually unchanged into the early 20th century, was used approvingly by Pavlov (1928) to explain differences in conditioning among dogs. Remnants of Galen’s views on temperament can be seen in some contemporary approaches (e.g., Kagan, 1994).

Until relatively recently, according to several scholars (e.g., Green, 1951), Galen’s contributions have been seriously underestimated. However transiently, Galen saw the value of experimentally manipulating environmental conditions in a single subject to differentiate between two competing hypotheses and recorded it in his writings. Not only does his use of behavioral measures to index internal states suggest that he was an early practitioner of behavioral medicine, but his use of a single-subject reversal design clearly supports his candidacy as the first user of a reversal design. As Green (1951) stated, “Some of [Galen’s] ideas are positively modern and show startling anticipation of future discovery. Actually, Galen was a thousand years ahead of his time, and it took mankind over 10 centuries to catch up with him” (pp. xiii–xiv). In some cases, it took mankind closer to 18 centuries to catch up.

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